
Estimation of Portion Sizes by Elderly Respondents

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This two-phase study assessed the cognitive strategies used by the elderly (individuals 65 years of age and older) and the accuracy of their estimates of reported dietary intake. In phase I of the study, we conducted interviews with 118 elderly respondents who were asked to “think aloud” while estimating the portion size of solid, liquid, and amorphous (i.e., nonspecific) foods they had eaten the previous day. Respondents were given one of four sets of estimation aids, although most chose not to use these and appeared confident in estimating amounts. In phase II, 90 different elderly participants ate lunch at a university facility. Food items were pre-weighed or measured before being served, and amounts consumed were calculated after each meal. The following day, researchers interviewed participants by using one of three randomly assigned methods: by telephone with mostly 2-dimensional aids, by telephone without aids, or in person with 3-dimensional aids. Participants were asked to recall what they had eaten at the meal and to estimate the amount eaten. Findings from phase I suggested that elderly respondents generally chose not to use an aid to estimate portion sizes. For most foods consumed in phase II, those participants who used an aid did not have reduced estimation errors, because these commonly exceeded ± 25 percent.

An understanding of food consumption and the challenges associated with changing consumption patterns are critical to improving human health and well-being. One barrier to understanding consumption is the difficulty in measuring what people eat. Dietary recall studies, such as the National Health and Nutrition Examination Survey (NHANES) and the Continuing Survey of Food Intakes by Individuals (CSFII), have been used extensively (Thompson & Byers, 1994) to estimate food consumption and to give insight into dietary inadequacies. However, some nutrition researchers have questioned the accuracy and validity of portion-size estimation to quantify dietary intake (e.g., Cypel, Guenther, & Petot, 1997). It is important that dietary data such as portion-size estimation be as accurate as possible (McGuire,

Chambers, Godwin, & Brenner, 2001; Mertz, 1992; Young & Nestle, 1995). Other authors have suggested that the accuracy of information obtained from older respondents may be lower than that obtained from younger ones (Taylor-Davis & Smiciklas-Wright, 1993). If this is true, the data used to determine the critical diet-related issues facing the elderly population may be less accurate than desired. This is of added importance because the proportion of elderly in the population is rising annually (U.S. Bureau of the Census, 1994).

Dietary recall places substantial cognitive demands on the respondent—requiring an in-depth search of memory, estimation, and judgment skills (Baranowski & Domel, 1994; Fries, Green, & Bowen, 1995). Until recently, little has been known about

these cognitive demands (Buzzard & Sievert, 1994). Hence, the National Center for Health Statistics (NCHS) has cited the need for additional research in this area (U.S. Centers for Disease Control, 1994). A better understanding of cognitive strategies (i.e., the ways in which people access and recall information) used during the recall process could help to design survey questions and interview procedures—and improve recall. These strategies, however, are not well understood, especially in older population groups. Recent information suggests that adults age 18 to 65 use various cognitive strategies when recalling portion sizes of foods eaten the previous day (Chambers, Godwin, & Vecchio, 2000). Understanding the cognitive strategies for estimating portion size is important information to have when developing effective estimation methods for procedures such as the 24-hour dietary recall, a technique used in many nutrition studies. Currently, there is little information about the cognitive strategies used by the elderly and how accurately they estimate portion sizes.

It is unclear whether using aids to help respondents estimate portion sizes increases accuracy for the elderly. Although these aids have the potential to provide an accurate, convenient means of estimating food portions, some research has indicated the accuracy of estimations may not improve with certain foods when aids are used (Godwin et al., 2001). The purpose of this research, therefore, was to gain a better understanding of the process that elderly respondents use to estimate portion sizes and to determine if aids used to estimate portion sizes improve these respondents' accuracy in saying how much they had eaten.

Methods

Phase I

Four highly trained interviewers conducted one-on-one interviews with 118 respondents age 65 years or older. Respondents were recruited from existing consumer-testing databases; by referral from associates; and through advertisements posted in health departments, churches, schools, and businesses. Of the 118 respondents, 75 percent were women; 65 percent were White, 32 percent were Black, and 3 percent were of other racial origins.

Because strategies for estimating portion size could be affected by the aids shown to participants, four sets of aids were used, with about 30 respondents assigned to each specific set. The aids represented various 2- and 3-dimensional aids for estimating portion sizes that have been used in the CSFII and NHANES studies as well as new aids that have been available to nutritionists, such as a book of photographs of portion sizes (Hess, 1997). The first set consisted primarily of 2-dimensional aids in a booklet that included full-size drawings of bowls, cups, plates, and glasses; three diagrams of geometric shapes—a muffin-shaped grid, cylindrical diagram, and circles; and a tool for estimating portions of wedges. Actual measuring cups and spoons and a ruler also were included.

The second set included mostly 3-dimensional aids such as actual bowls, cups, plates, glasses, measuring cups and spoons, bean bags in four sizes, a ruler, and sticks for estimating thickness. Also included in this set were a muffin diagram, the cylindrical diagram, and the tool for estimating portions of wedges. The third set included photographs (Hess, 1997) of portions of 35 representative foods

(e.g., cooked mixed vegetables were used to represent any cooked vegetable), a ruler, the muffin and cylindrical diagrams, the wedge tool, and measuring cups and spoons. The fourth set included photographs (Hess, 1997) of household vessels (e.g., bowls, cups, plates, and glasses), a ruler, the muffin and cylindrical diagrams, the wedge tool, and measuring cups and spoons. During interviews, the aids from one of the four sets were arranged randomly in front of respondents, to avoid having the position of the aid create bias.

We used the respondents' age, gender, and race to balance their assignment to a test group of portion-size aids. Interviewers were trained to use any of the portion-size aid sets in an interview. To enable researchers to categorize the cognitive processes used in remembering portion sizes, respondents used a think-aloud process (Ericsson & Simon, 1984) during the interview, with them verbally describing their strategies for deciding how much of each food they ate. To facilitate the procedure and to help respondents understand the task and become acquainted with the procedure, we asked each respondent to complete two practice think-aloud activities—arranging five cards of various shapes from smallest to largest and matching colors to shapes. Respondents were reminded to think aloud if they were not doing so—to verbalize everything they were thinking. If a respondent hesitated, the interviewer asked nonsuggestive questions that would help the person describe his or her thought process.

Procedures for the initial dietary interview were adapted from those used in the CSFII (Tippett & Cypel, 1998). The multi-pass approach we used gave respondents several opportunities to provide details about the foods they had consumed. In the first pass, respondents were asked to recall foods they

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consumed the previous day. For further questioning, the interviewer used the information from the first pass to select at least two foods, if possible, from three categories (solid shapes such as steak or cornbread, liquids such as water or juice, and amorphous¹ shapes such as cooked vegetables or macaroni and cheese). The interviewer then uncovered and introduced the set of aids assigned to that respondent. The interviewer showed the respondent each aid, briefly described its use, and informed the respondent that he or she could use any of the aids during the interview or could express in any other way the amounts of food consumed.

In the second pass, the interviewer asked a series of questions about each selected food, including the amount consumed. During or immediately after the question on the amount consumed, interviewers used several questions to help respondents think aloud to describe how much was eaten. Questions such as the following were used: “What were you thinking when you were remembering the amount you ate/drank? What made you choose that aid? I see you picked up an aid, then put it back down and selected another. What was going through your mind as you did that?”

Next, the interviewer reviewed the respondents’ response for each food item consumed and followed up with more specific questions. Cognitive think-aloud techniques were also used during this pass when the interviewer tried to obtain information about the usefulness of various food estimation aids. If the respondent used an aid, it was removed by the interviewer, who then asked the respondent, “If that aid was not available, was there anything else that could be used, either another

aid in the set or something else, to help you describe how much you ate/drank of the food/drink?” The interviewer kept the respondent talking about his or her thoughts and the reasons certain aids were used and others were not. In addition, respondents were asked to describe other aids that would be helpful; however, none did.

Data Coding and Analysis

Each interviewer recorded the aids that the respondents used during the interview to describe the amount of each food consumed the previous day; the reviewer also kept notes about both verbal and nonverbal cognitive strategies used by respondents. Each interview was audiotaped also. Using a modified ethnographic approach (Stewart & Shamdasani, 1990; Morgan, 1990), we developed a list of potential cognitive strategies or “themes” after debriefing the interviewers and listening to tapes from 10 preliminary interviews. Those strategies were compared with the ones described by Chambers et al. (2000); no new strategies were found.

Each audiotape of phase I interviews was replayed and compared with the data recorded by the interviewer. Cognitive recall strategies were then classified (table 1) by using the criteria established by Chambers et al. (2000), and the aids used for each food item were recorded and coded for summary. Content analysis was conducted by counting the responses that fit the identified strategies. Because qualitative research generally is perceived to be more exploratory than quantitative, the numerical data presented is less important than the themes that emerge from the research (Betts, Baranowski, & Hoerr, 1997).

¹ Amorphous foods were semisolid or solid foods for which amounts of the food do not have a specified shape; consequently, the foods mound or take the shape of the container.

Phase II

In this phase, 90 different participants, age 65 and over, ate lunch from a limited buffet selection at a university research facility. Food items, consisting of roast beef, mashed potatoes, gravy, green beans, macaroni and cheese, tossed salad, cornbread, cake, iced tea, and appropriate condiments, were pre-weighed or measured before being served to the participants.

Before phase II began, actual weight equivalents for measured foods were determined. Because leftover foods were measured at room temperature, weight equivalents for hot foods also were taken at room temperature to account for evaporative losses.

Amounts eaten were calculated after each meal by weighing leftovers and subtracting that amount from the original or cooled weight.

Participants were interviewed the day after having consumed lunch at the facility. During these interviews, researchers used a similar procedure to that described in phase I, but without the cognitive probing. Participants were asked to recall what they had eaten at lunch the previous day and to estimate the amounts and were then randomly assigned to one of three interview groups.

Participants assigned to group A were interviewed by telephone and did not use portion-size aids to recall the amounts eaten. Participants assigned to group B were interviewed by telephone and used aids appropriate for that type of interview. These included a 2-dimensional food model booklet (USDA, 2001) containing life-size drawings of glasses, cups, bowls, and shapes (e.g., mounds, a wedge tool with a moveable arm to denote size, and a grid), measuring cups and spoons, and a ruler. Participants assigned to group C were interviewed and used aids

Table 1. Strategies elderly respondents used to report portion size

Strategy ¹	Liquids		Solid foods		Amorphous foods	
	First ²	Follow-up ³	First ²	Follow-up ³	First ²	Follow-up ³
	<i>Percent</i>					
Known amount purchased	15	0	2	1	3	1
Known amount measured	10	6	0	1	13	5
Estimation based on a known amount	20	8	4	3	5	3
Estimation based on a previous amount	1	0	0	0	3	0
Estimation (guess)	2	4	1	2	2	5
Counting number of items	9	5	28	5	14	5
Visualization of size	0	0	45	24	2	2
Visualization of volume	14	26	2	5	24	21
Visualization of container	19	20	3	7	17	12
Visualization of action ⁴	10	0	13	12	17	1
Visualization, compare size to aid ⁵	0	3	1	34	0	1
Visualization, compare volume to aid ⁵	0	28	1	5	0	34
Visualization, compare container to aid ⁵	0	0	0	1	0	10

¹Strategies are described by Chambers et al. (2000) and were re-evaluated for this study during development of the methods.

²First strategy identified by respondents without the interviewer probing for additional information.

³Follow-up strategy identified by respondents after the interviewer probed for additional information.

⁴Motions used to help determine the number of pieces, scoops, or spoonfuls eaten.

⁵Strategies that used a portion-size estimation aid.

appropriate for in-person interviews—mostly 3-dimensional aids such as glasses, bowls, measuring cups and spoons, bean bags, sticks to estimate thickness, a ruler, the wedge with moveable arm, and size grid. The participants in groups B and C were guided to aids that they might find appropriate for estimating portion sizes of foods. For example, participants were guided to bowls, mounds, and measuring cups for estimating the portion size of mashed potatoes. The groups of aids for phase II were determined based on results from phase I. Aids that were unused or clearly not liked by the elderly were eliminated.

Data Analysis

We calculated percentage estimation errors² and used procedures outlined by SAS (2001) to analyze variance with least significant differences³ for mean percentage estimation error, frequencies, and Pearson correlation coefficients. Outliers beyond three standard deviations of the overall average for a particular food were not included in analyses for mean percentage estimation error for that food, an important consideration, because large deviations in a single respondent's data could have a major effect on the mean data for that food. Removal of these outliers resulted in less than 1 percent of the data being excluded from the analysis.

²Percentage estimated errors = ((estimated weight (g) - measured weight (g))/measured weight (g)) x 100.

³General Linear Model and Probability of Difference procedures.

For all types of food, average estimation errors ranged from -29.9 (no aids for cornbread) to +29.3 percent (3-D aids for cake) . . . , indicating that, depending on the food and procedure (e.g., aids or no aids), portion sizes of foods may be under- or overestimated.

Results and Discussion

Phase I

Respondents used numerous strategies to assist in recalling the foods they had eaten and in estimating the portion sizes (table 1). In this study, the methods used for estimation were categorized into 13 distinct strategies, illustrating the diversity of cognitive approaches used to estimate portion size.

For the first portion estimation (without follow-up questions from the interviewer), respondent use of the aids was minimal—using aids to estimate portion sizes for only 2 percent of the estimations for solid foods. Aids were not used as a first strategy for recalling portions for liquids or amorphous foods. Respondents' comments during the interviews indicated that the minimal use of aids was related to several factors: extensive food preparation knowledge, considerable experience with special diets, or the use of easily identified portions. Comments were made such as: "I have cooked all my life and know what ½ cup is," "I'm on a special diet and used to have to measure my salad dressing, so I have a pretty good idea how much to put on," and "I know I ate half a can of tuna because I made the tuna salad from one can and ate half yesterday and half today."

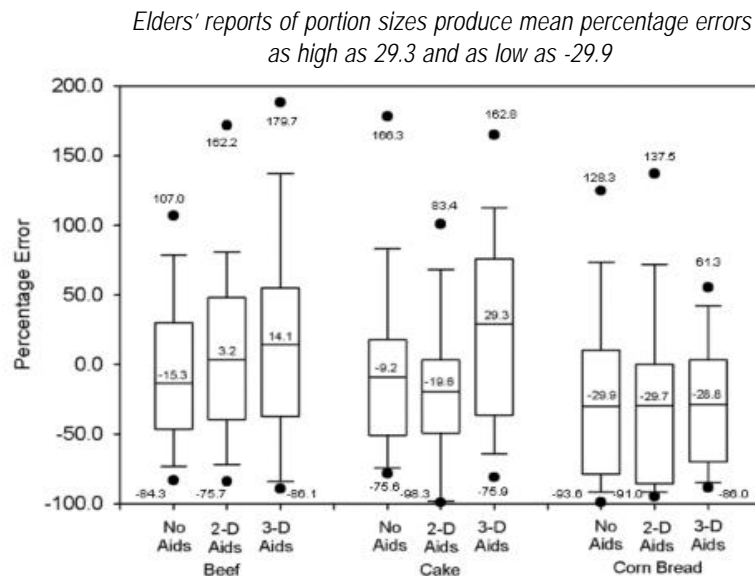
These findings are different from those reported for younger respondents in a study by Chambers et al. (2000). In that study, younger respondents indicated that aids used to estimate portion size represented a good way of reporting amounts that were hard to describe without aids. Perhaps, the elderly are better at estimating portion size because they are less likely than are younger Americans to eat away from home (Wilson et al., 1997). Shatenstein, Payette, Nadon, and Gray-Donald (2002) suggest that food-related

memory appears to be linked to dietary knowledge, food preparation experience, and prior acquaintance with the foods. Collectively, these findings suggest that, when given the choice, elderly individuals do not believe they need to use aids to estimate the portion size of the foods they have consumed; whereas, younger individuals think these aids are helpful in some cases.

For all types of foods, visualization of portions without use of an aid was common for the initial estimation by elderly respondents. When interviewers used probing questions to solicit an exact portion, the elderly simply gave amounts such as 16 ounces of iced tea, 1 cup of green beans, 1 slice of "brand x" cheese or bologna, and a 2"x3" "square" of cake. However, the follow-up strategy for elderly respondents was to use the estimation aids for portion sizes. This suggests that the use of these aids was comfortable for most elderly respondents; they just did not believe they needed one.

For liquids, the strategy used most commonly for determining portion size was estimation based on known amount. An example of this strategy includes the following: "I bought a 12-ounce can and drank half of it." Almost half of estimations for liquids involved known amounts either purchased or measured (25 percent) or estimations based on known amounts (20 percent) (e.g., "I used to have to measure how much water I drink, but now I just always use the same set of glasses that I know hold 16 ounces"). Estimations based on known amounts are good for reporting portion size and do not require an aid, but they cannot be used in many situations where the original volume is unknown. For the follow-up estimation, an aid to estimate portion size was the most popular reporting strategy used by the elderly respondents to visualize the amount of foods they had consumed.

Figure. 1. Distributions¹ of percentage errors for representative solid foods



¹From bottom to top: The horizontal lines represent the 10th and 25th percentiles, mean, and 75th and 90th percentiles, respectively. Points represent the 5th and 95th percentiles, respectively.

The first strategy for reporting the portion size of solids involved visualizing the size: 45 percent of all estimation of solids. This strategy often involved the respondents using their hands as a reference for estimating the portion size. Another 28 percent of the respondents used a counting strategy (e.g., 1 slice of bread or cheese, 2 “brand x” hot dogs, and 1 “brand x” biscuit. Although counting also was used by nonelderly adults in a study by Chambers and colleagues (2000), it may be more prevalent with elderly respondents who tended to eat smaller portions, ate more defined food (i.e., fewer mixtures with unknown recipes), and ate pre-portioned food from larger packages. For the follow-up estimation for solid foods, one in three elderly respondents chose to use an estimation aid to assist in visualizing the portion size of the foods they had consumed. Usually, those aids were the size grid, ruler, or the wedge estimation aid—all of which were used to estimate the

dimensions of the food. This strategy, using aids to visualize portion sizes, was similar to that reported for younger adults (Chambers et al., 2000).

For amorphous foods, about one-fourth (24 percent) of the elderly respondents’ first estimations involved visualizing the volume and another 17 percent involved visualizing the container. Respondents who used either of these two methods then compared the visualizations with a mental picture of a measuring utensil (e.g., an image of a measuring cup) to estimate and report amount. For the follow-up, 34 percent used one of the available aids such as a measuring cup or bowl, as a comparison for volume estimation.

The differences in respondents’ strategies between the first and follow-up estimations suggest that the prevalence of aids used by the elderly to estimate portion sizes may be dependent on whether a guided

interview is used. Findings suggest that the elderly might use these aids if guided to do so. Based on this study, using aids to estimate portion sizes as part of an unguided interview may be ineffective with the elderly because most of the respondents did not choose to use them. These respondents stated that the aids were unnecessary because they already could estimate the portion size of the foods they consumed. In follow-up questions by the interviewers, elderly participants were more likely to use a 3-dimensional aid or a grid than a 2-dimensional photograph or drawing. The elderly in this study particularly disliked the photographs of food, because the photographs were of “representative” foods and not necessarily the food the participant had consumed. This belief could limit severely the use of photographs with elderly respondents, because of the possible difficulty of having photographs of every food respondents may have eaten.

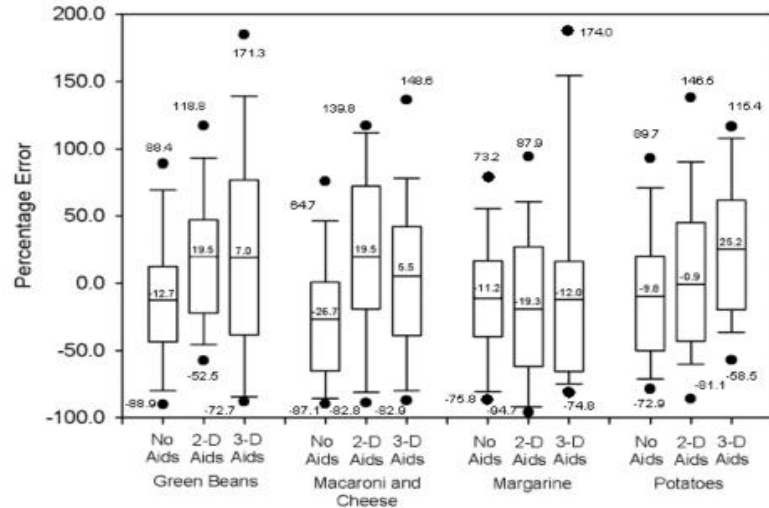
During phase I, we did not determine whether the elderly were more accurate when using estimation aids than when they did not. Because the accuracy of the estimations associated with using aids for portion estimation is an important factor in developing the most effective data collection methods for elderly individuals, we conducted phase II of this study to determine accuracy of estimation when various interview techniques and aids to estimate portion size are used.

Phase II

For all types of food, average estimation errors ranged from -29.9 (no aids for cornbread) to +29.3 percent (3-D aids for cake) (fig. 1), indicating that, depending on the food and procedure (e.g., aids or no aids), portion sizes of foods may be under- or overestimated. Individually, participants had difficulties accurately estimating portion sizes of each food.

Figure 2. Distributions¹ of percentage errors for representative amorphous foods

Elders' reports of portion sizes produce mean percentage errors as high as 25.2 and as low as -26.7



¹From bottom to top: The horizontal lines represent the 10th and 25th percentiles, mean, and 75th and 90th percentiles, respectively. Points represent the 5th and 95th percentiles.

Overall, the use of either 2- or 3-dimensional aids to help elderly participants determine food portion sizes did not significantly improve the accuracy of their estimations.

Of the more than 100 individual estimates of portion sizes reported in this study, more than 75 percent exceeded estimation errors of ± 20 percent (data not shown). Some individual estimation errors approached -100 percent or +200 percent (figs. 1 and 2). Average estimation errors generally were lower for the beverages (data not shown), compared with the solid and the amorphous foods (figs. 1 and 2), but the range of response inaccuracy still was high.

Overall, the use of either 2- or 3-dimensional aids to help elderly participants determine food portion sizes did not significantly improve the accuracy of their estimations. This suggests that providing commonly used aids may not be a particularly effective method for obtaining portion-estimation information from the elderly. In phase I, elderly respondents chose not to use an aid to estimate the portion size of the

food they consumed for more than 95 percent of the first-interview estimations. In phase II, their use of either 2- or 3-dimensional aids did not consistently increase the accuracy of their estimations. Therefore, other strategies may be necessary for the elderly to estimate portion sizes.

A cautionary note is warranted in the interpretation of these findings: It is likely that using a non-home environment (in this case, a university research facility) for testing affected the portion-estimation strategy used by the respondents and the accuracy of their estimations. A common strategy used by the elderly—"known amounts" based on purchase, preparation, or measurement—could not be used when the participants came to the facility to eat a meal. Because the "known amounts" strategy may help with accuracy, results from "at-home" testing could show greater accuracy.

This research did not, however, investigate that possibility. Further research that uses in-home testing will need to be conducted to understand this issue better.

Conclusions

In this research, elderly respondents used numerous strategies to estimate portion sizes of the foods they consumed, but almost all (more than 95 percent) of the respondents in phase I chose *not* to use an aid to help with that estimation when first asked about portion size. Guiding participants to aids increased their use of aids in phase II but did not consistently increase the accuracy of their estimations for any type of food consumed. These findings suggest that for elderly respondents, aids that often have been used to estimate portion size may not be needed. To provide greater accuracy, new techniques for portion-size estimation or new aids may be needed. The use of alternative techniques, such as estimations using an expanded category scale (e.g., 5- to 10-point scales for small, medium, and large), may be effective and is one idea that needs to be investigated.

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